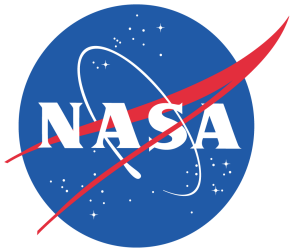
# Overview of Air Quality Applied Sciences Team

**Loretta J. Mickley, Harvard University**

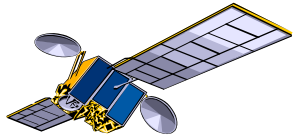




NASA Health and Air Quality Applications Program Review
Sept. 18-20, 2012
Newport RI

# Air Quality Applied Sciences Team (AQAST)

NASA initiative, begun in 2011, builds a bridge between Earth science resources and air quality management needs.

**Earth science resources**



satellites

suborbital platforms

models

AQAST

**Air Quality Management Needs**

- **Pollution monitoring**
- **Exposure assessment**
- **AQ forecasting**
- **Source attribution of events**
- **Quantifying emissions**
- **Nat & foreign influences**
- **AQ processes**
- **Climate-AQ interactions**

# AQAST members

- **Daniel Jacob (leader)**, Loretta Mickley (Harvard)
- Greg Carmichael (U. Iowa)
- Dan Cohan (Rice U.)
- Russ Dickerson (U. Maryland)
- Bryan Duncan, Yasuko Yoshida, Melanie Follette-Cook (NASA/GSFC); Jennifer Olson (NASA/LaRC)
- David Edwards (NCAR)
- Arlene Fiore (NOAA/GFDL); Meiyun Lin (Princeton)
- Jack Fishman, Ben de Foy (Saint Louis U.)
- Daven Henze, Jana Milford (U. Colorado)
- Tracey Holloway, Steve Ackerman (U. Wisconsin); Bart Sponseller (Wisconsin DRC)
- Edward Hyer, Jeff Reid, Doug Westphal, Kim Richardson (NRL)
- Pius Lee, Tianfeng Chai (NOAA/NESDIS)
- Yang Liu, Matthew Strickland (Emory U.), Bin Yu (UC Berkeley)
- Richard McNider, Arastoo Biazar (U. Alabama – Huntsville)
- Brad Pierce (NOAA/NESDIS)
- Ted Russell, Yongtao Hu, Talat Odman (Georgia Tech); Lorraine Remer (NASA/GSFC)
- David Streets (Argonne)
- Jim Szykman (EPA/ORD/NERL)
- Anne Thompson, William Ryan, Suellen Haupt (Penn State U.)

Present at this meeting.

# AQAST organization

- **AQAST supports two types of projects:**
  - **Investigator Projects (IPs) -- core funding to individual members**
  - **Tiger Team Projects (TTPs) – collaborations between AQAST members with supplementary funding to address urgent air quality management needs.**

- **All AQAST projects bridge Earth Science and air quality management:**
  - **Use Earth Science resources with clear air quality management outcomes.**
  - **Team up with partners in air quality management.**

- **AQAST has flexibility in how it allocates its resources**
  - **Members can adjust their IPs to meet evolving air quality needs**
  - **Proposed Tiger Teams compete annually for funding to address the most pressing needs.**
  - **The team is self-organizing and can respond quickly to demands.**

**Quick, collaborative, flexible, responsive to the needs of the AQ community.**

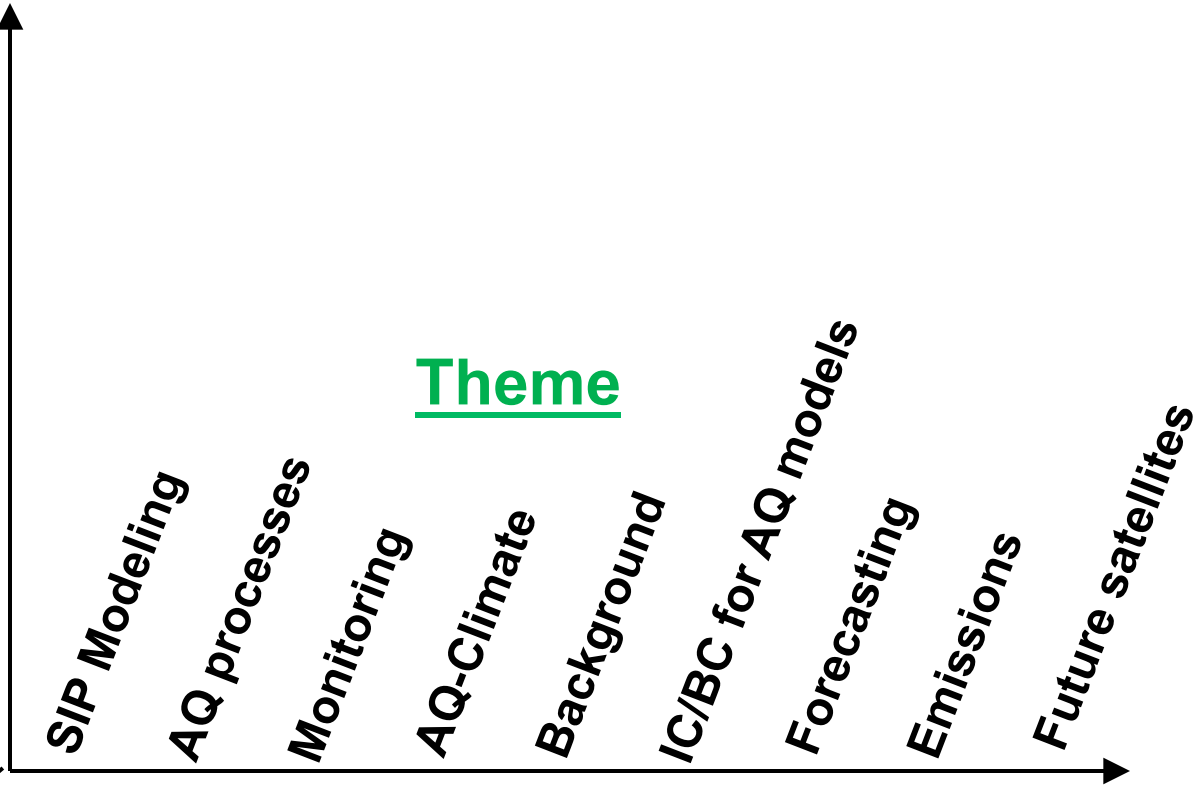
AQAST

NASA Air Quality Applied Sciences Team

# Scope of current AQAST projects

## Partner agency

- **Local**: RAQC, BAAQD
- **State:** TCEQ, MDE, Wisconsin DNR, CARB, Iowa DNR, GAEPD, GFC
- **Regional:** LADCO, EPA Region 8
- **National:** EPA, NOAA, NPS




**Satellites:** MODIS, MISR, MOPITT, AIRS, OMI, TES, GOES

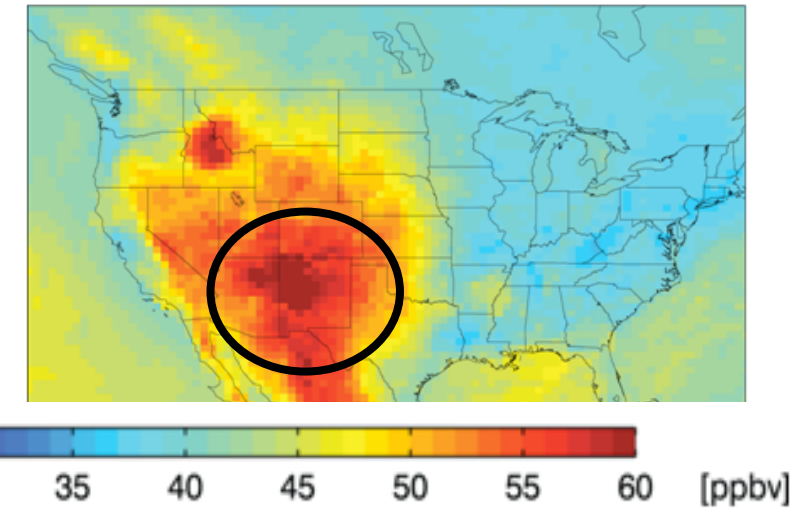
**Suborbital:** ARCTAS, DISCOVER-AQ, ozonesondes, PANDORA

**Models**: MOZART, CAM AM-3, GEOS-Chem, RAQMS, STEM, GISS, IPCC

## Earth Science resource

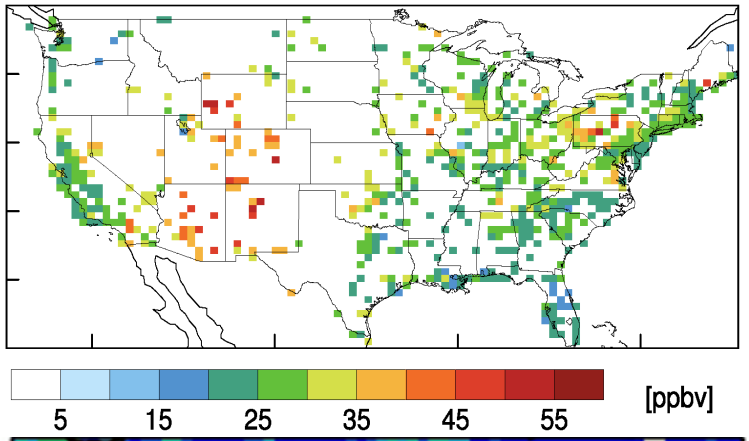
# AQAST Year 1 Highlight:

## Background ozone estimates for EPA Integrated Science Assessment




Annual 4th highest value of North American background ozone from GEOS-Chem model. [Zhang et al., AE 2011]

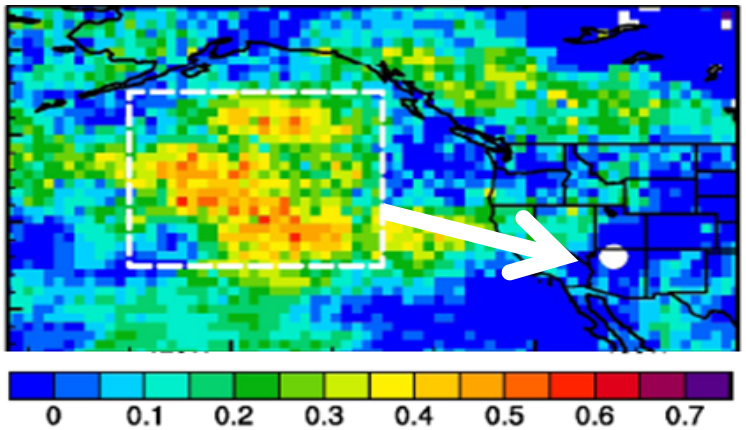
---




Annual maximum influence from stratospheric ozone, calculated by the GFDL AM-3 model and validated with observations.

Stratospheric intrusions can contribute to ozone exceedances. [Lin et al., 2012a].

---



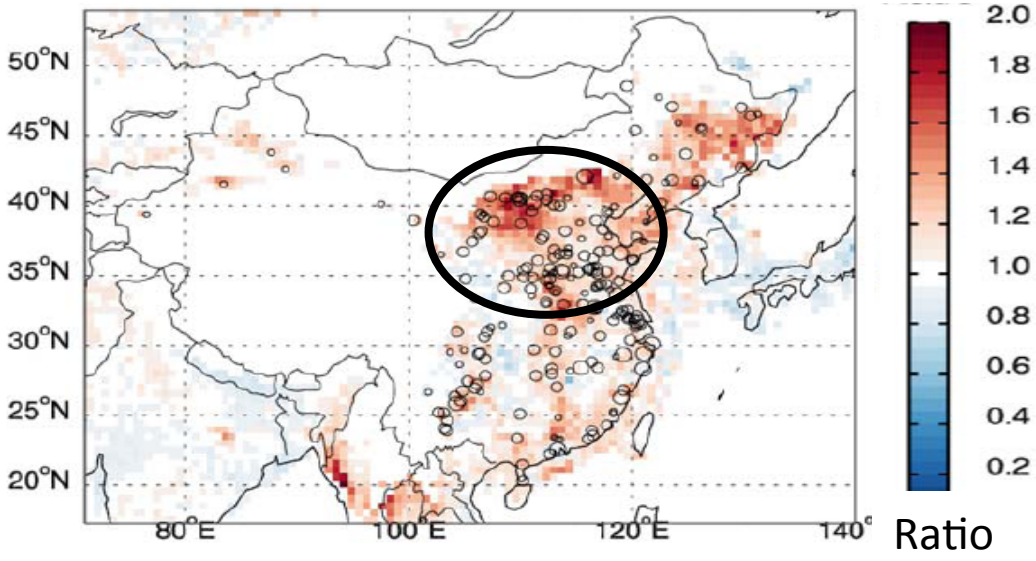

Correlation between AIRS satellite observations of CO over Pacific and the Asian ozone influence over western US two days later.

Satellite CO as an early warning indicator of Asian pollution [Lin et al., 2012b].

R

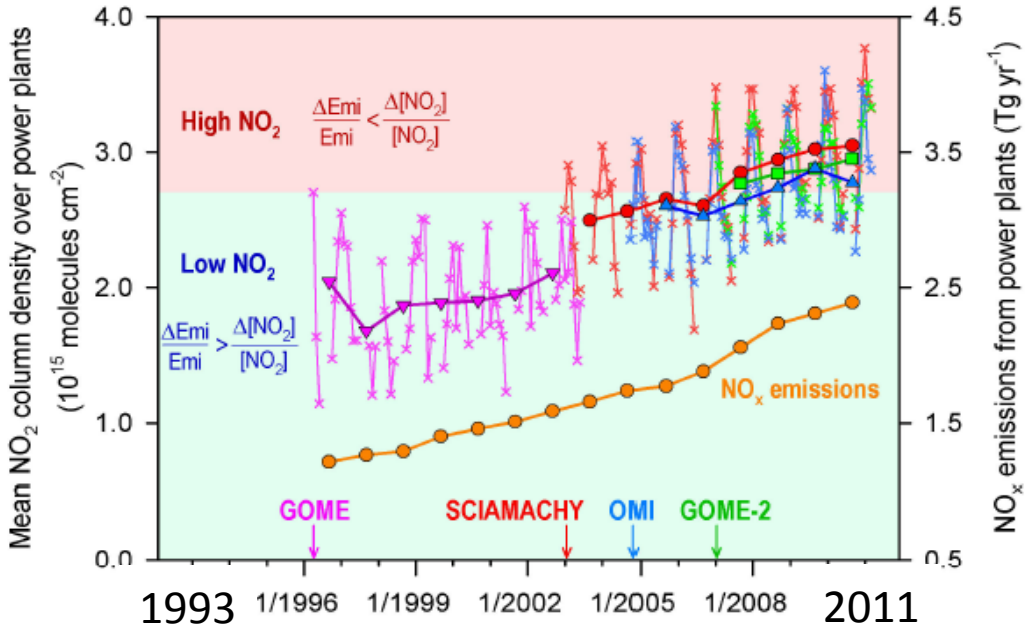
AQAST PIs: A.M. Fiore, D.J. Jacob

# *AQAST Year 1 Highlight*: Using satellite observations to monitor $NO_x$ emission growth in China and India




OMI $NO_2$ tropospheric columns, Ratio of 2007 / 2005 values.

Circles are new power plants. Capacities of coal-fired power generation increased ~50%. [Wang, Streets, et al., 2012]




OMI $NO_2$ tropospheric columns over Indian power plants regions, 1996-2010

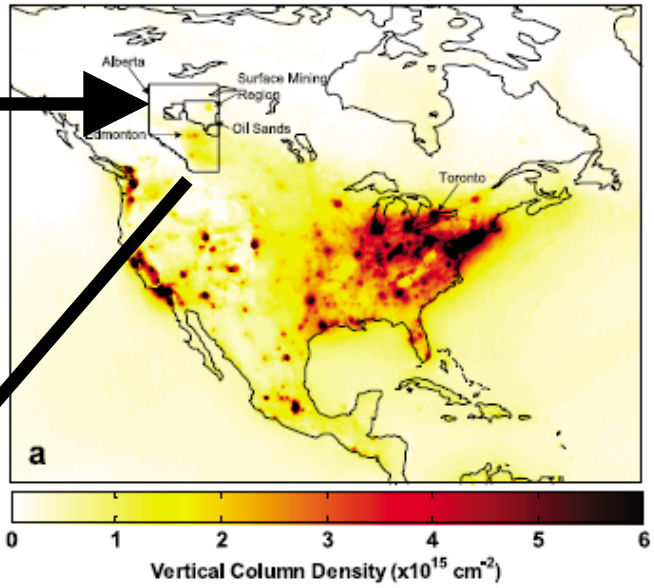
The observed 70% increase is consistent with a bottom-up emission inventory. [Lu and Streets, 2012]

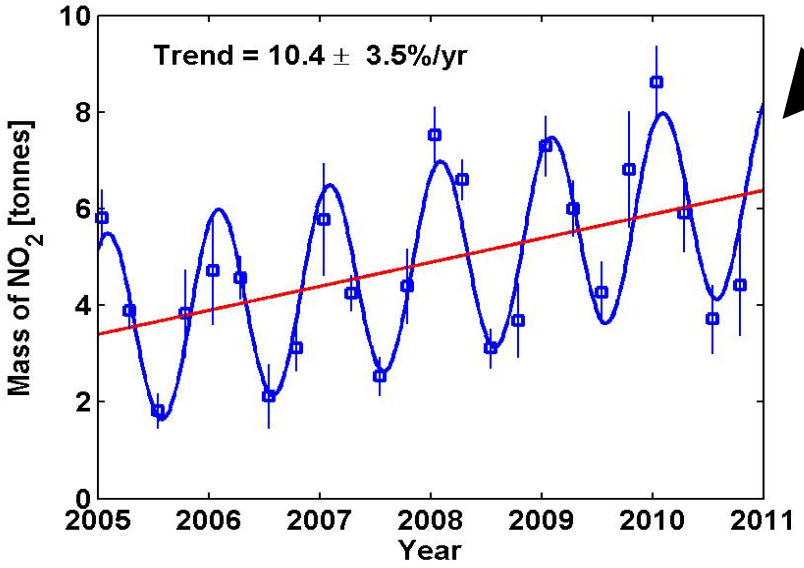
**AQAST PI: D.G. Streets**

# *AQAST Year 1 Highlight :* Using satellite observations to monitor growth in emissions from Canadian oil sands

Oil sand recovery In Alberta

OMI $NO_2$ columns, 2004-2010




Oil sand extraction requires much energy to extract and upgrade the bitumen.

Observations show an increase in $NO_2$ columns of ~10% per year.

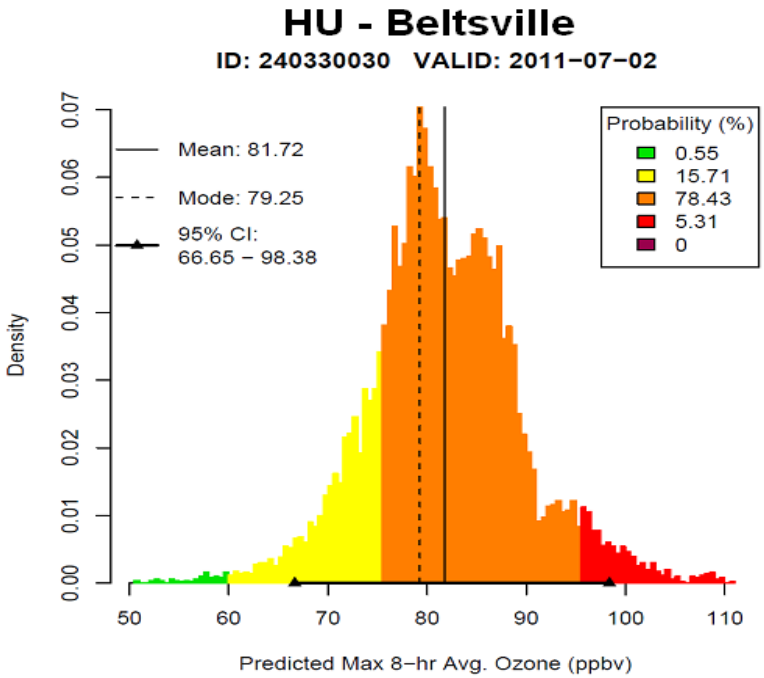
**McLinden et al. [GRL 2012]**

**AQAST PI: R.R. Dickerson**

# *AQAST Year 1 Highlight:* Forecast support for DISCOVER-AQ


**NASA P-3 aircraft**


Statistical ozone forecasts provided to Maryland Department of Environment (MDE) during DISCOVER-AQ, summer 2011.

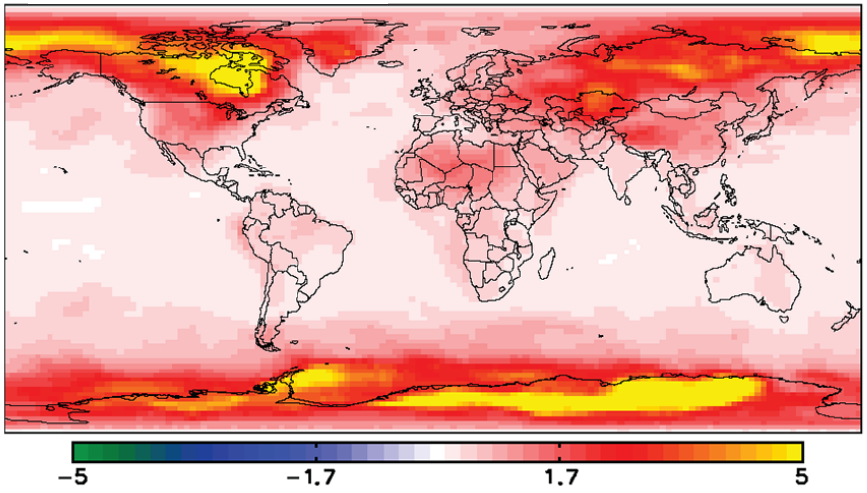



**Garner et al., in prep.**

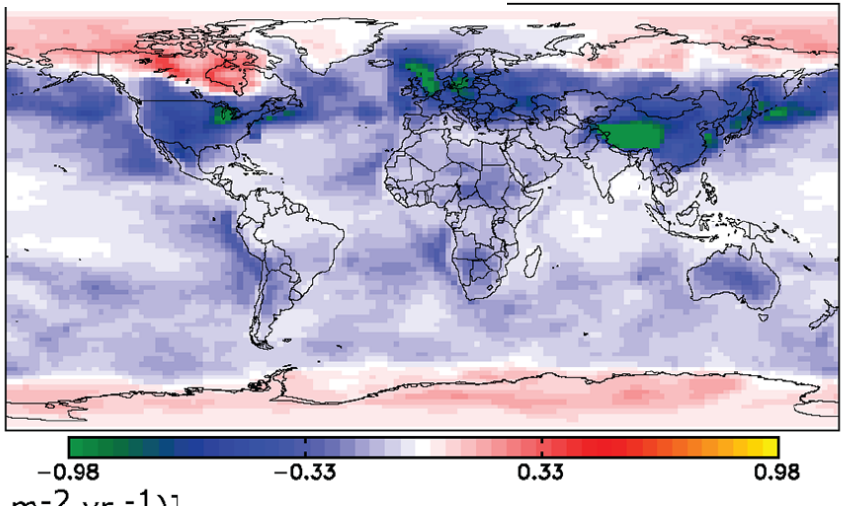
**AQAST PI: A.M. Thompson**

# *AQAST Year 1 Highlight:* Spatial variability of radiative forcing efficiency from anthropogenic emissions

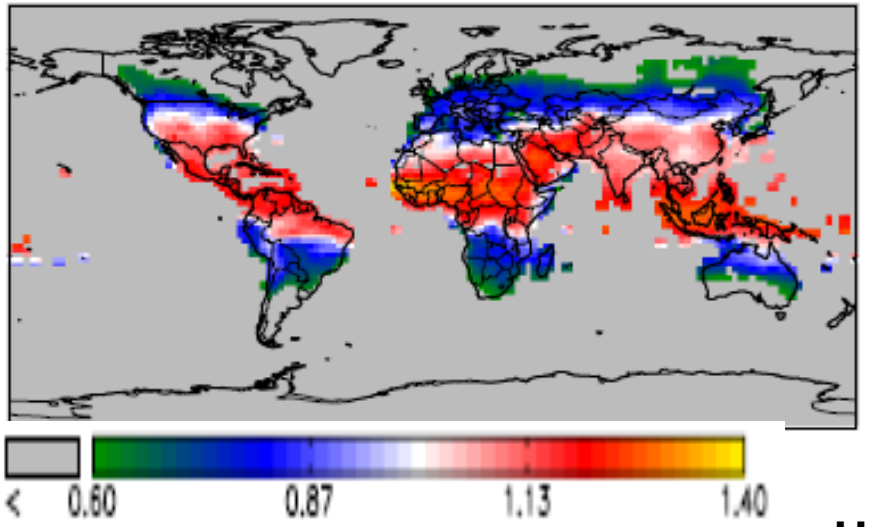
**BC emissions**




**Ammonia emissions**




**Ozone forcing efficiency from $NO_x$ emissions**




Aerosol radiative forcing efficiency calculated with the GEOS-Chem adjoint, W $m^{-2}$ / kg $m^{-2}$ $a^{-1}$

Radiative forcing efficiencies can vary spatially by a factor 4 across the US.

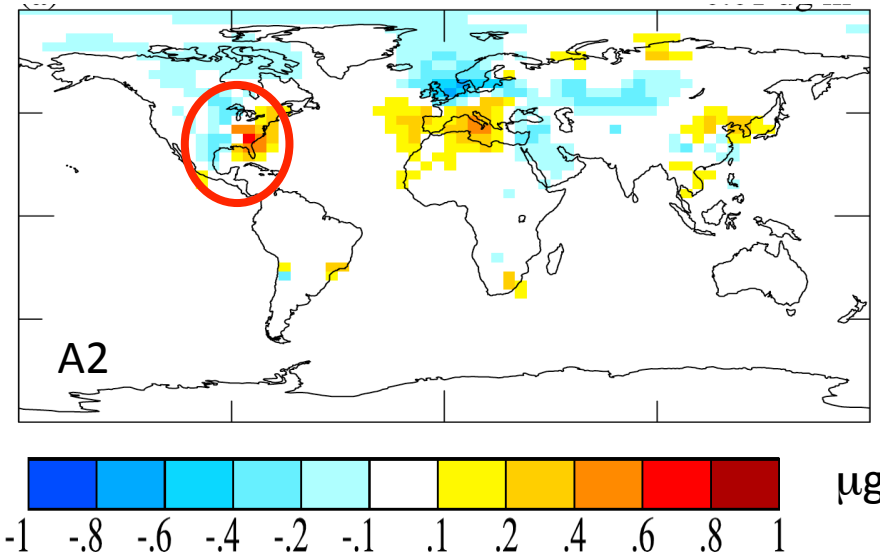
**AQAST PI: D.K.Henze**

**Henze et al.[2012], Bowman and Henze[2012]**

# *AQAST Year 1 Highlight:*

## Quantifying the effect of climate change on $PM_{2.5}$ air quality

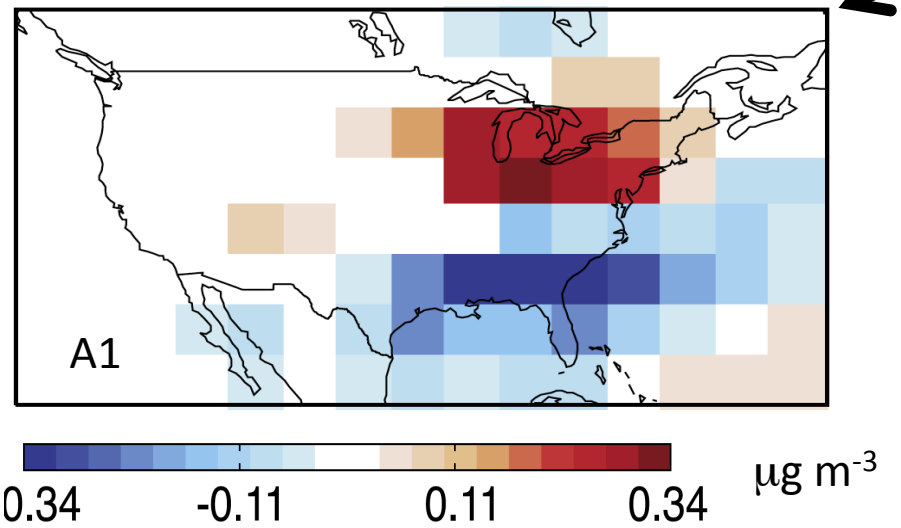
Racherla and Adams, 2006




Previously, models disagreed on the the magnitude and even sign of the impact of climate change on PM2.5.

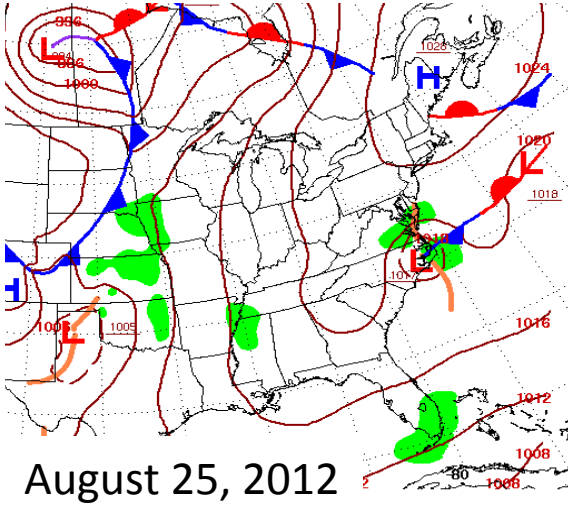
Response of PM2.5 to 2000-2050 climate change.

Pye et al., 2009



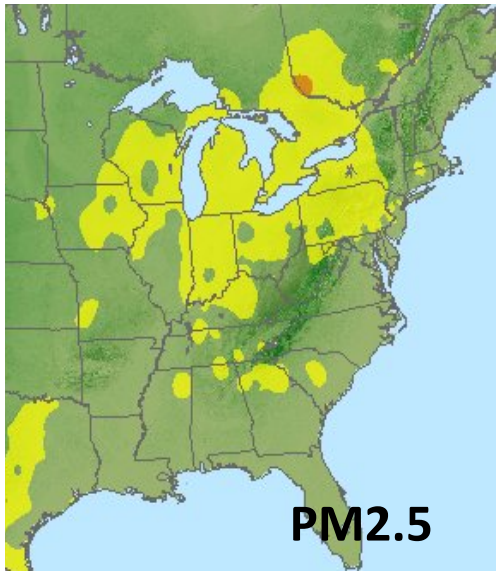

We need a simple tool that will allow AQ managers to readily calculate the climate penalty for PM2.5 air quality across a range of models and scenarios.

**AQAST PI: L.J. Mickley**

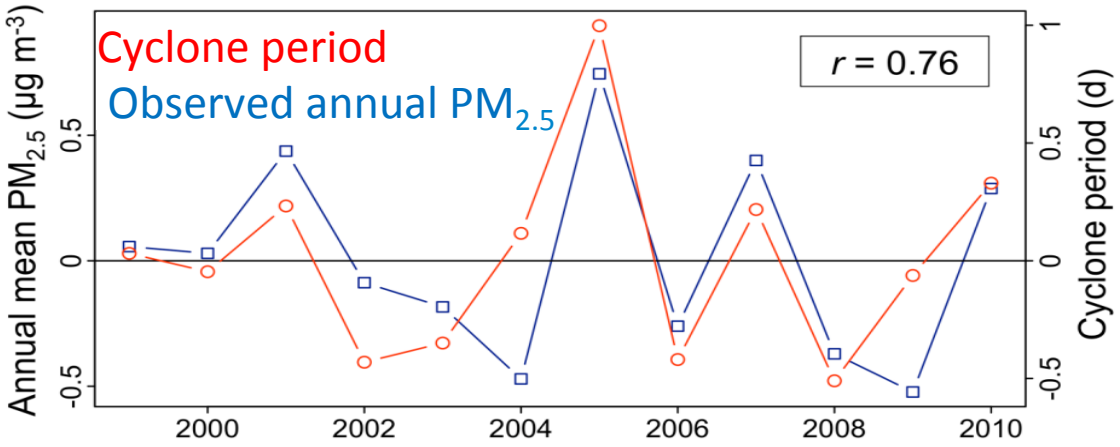


August 25, 2012

Principal component analysis shows that stagnation conditions elevate PM2.5 in Eastern US.

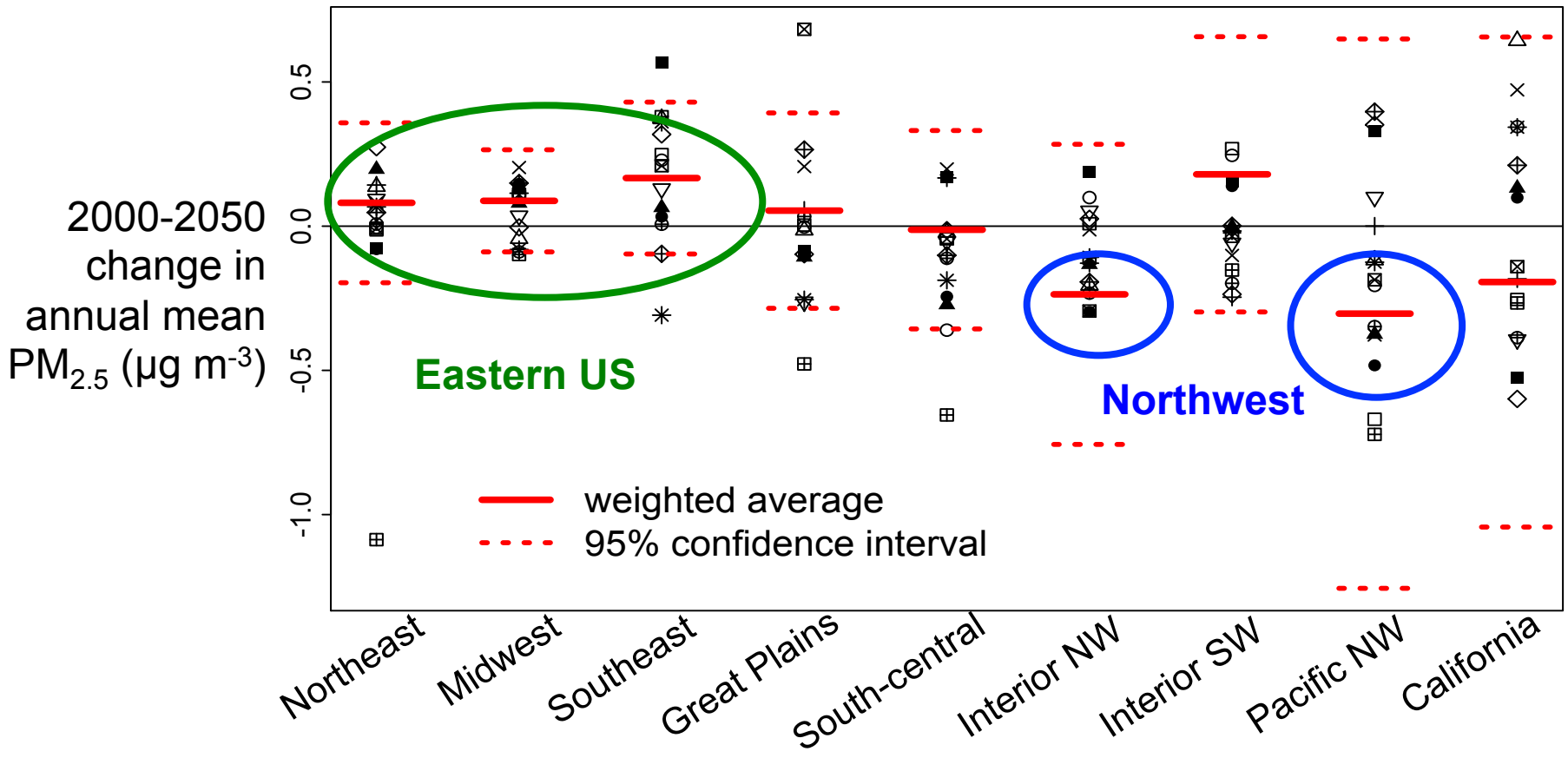



We found that detrended interannual variability of $PM_{2.5}$ in Midwest is correlated with cyclone period.




We examined 2010-2050 trends in cyclone period in the AR4 model ensemble.

# Models disagree on the sign and magnitude of projected change in annual mean PM2.5, but some patterns emerge.




Likely responses:

- Increase of ~0.1 μg $m^{-3}$ in eastern US due to increased stagnation
- Decrease of ~0.3 μg $m^{-3}$ in Northwest due to more frequent maritime inflows

# *AQAST Year 1 Highlight:*

# Quantifying the effect of climate change on $PM_{2.5}$ air quality

Effect of fires on $PM_{2.5}$ will likely have the largest impact in 2050s, especially regionally.

**Circulation**
Tai et al. 2012

**Temperature**
Heald et al, 2008; Pye et al., 2009; Tai et al., 2012a

**Vegetation**
Wu et al., 2012

**Wildfires**
Spracklen et al., 2009; Yue et al., 2012

East

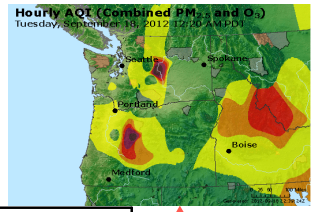
Northwest

Southeast (OC)

Southeast (nitrate)

Midwest + West

Northwest




-0.6 -0.4 -0.2 0.0 0.2 0.4 0.6

2000-2050 change in annual mean $PM_{2.5}$ ($\mu g\ m^{-3}$)

**Tai et al. [2012 a,b]**
**AQAST PI: L.J. Mickley**

**PM2.5 air quality, 18 Sept 2012**

# *AQAST Year 1 Highlight:* The Iowa Landfill Fire of 2012

Uncontrolled landfill liner fire within 5 miles of >150K people

- 7.5 acres burned, May-June 2012
- 1.3 million shredded tires
- Irritants + mutagens + $SO_2$ + 5-80 μg/$m^3$ PM2.5

AQAST Nowcasting tool helped policymakers decide public health response & favorable conditions for fire intervention

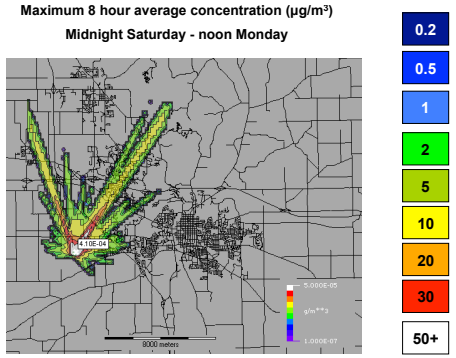
- WRF-Chem + GSI 3DVAR 72hr forecast assimilating NASA retrievals.

+ AERMOD @ 100 m

+ emissions factors from mobile monitoring by 3 groups

= New decision support toolkit for **rapid** public health response to urban toxic releases

**AQAST PIs: Carmichael, Spak**




# Communication Tools

- **Website: http://acmg.seas.harvard.edu/aqast**


## AIR QUALITY APPLIED SCIENCES TEAM (AQAST)

***EARTH SCIENCE SERVING AIR QUALITY MANAGEMENT NEEDS***

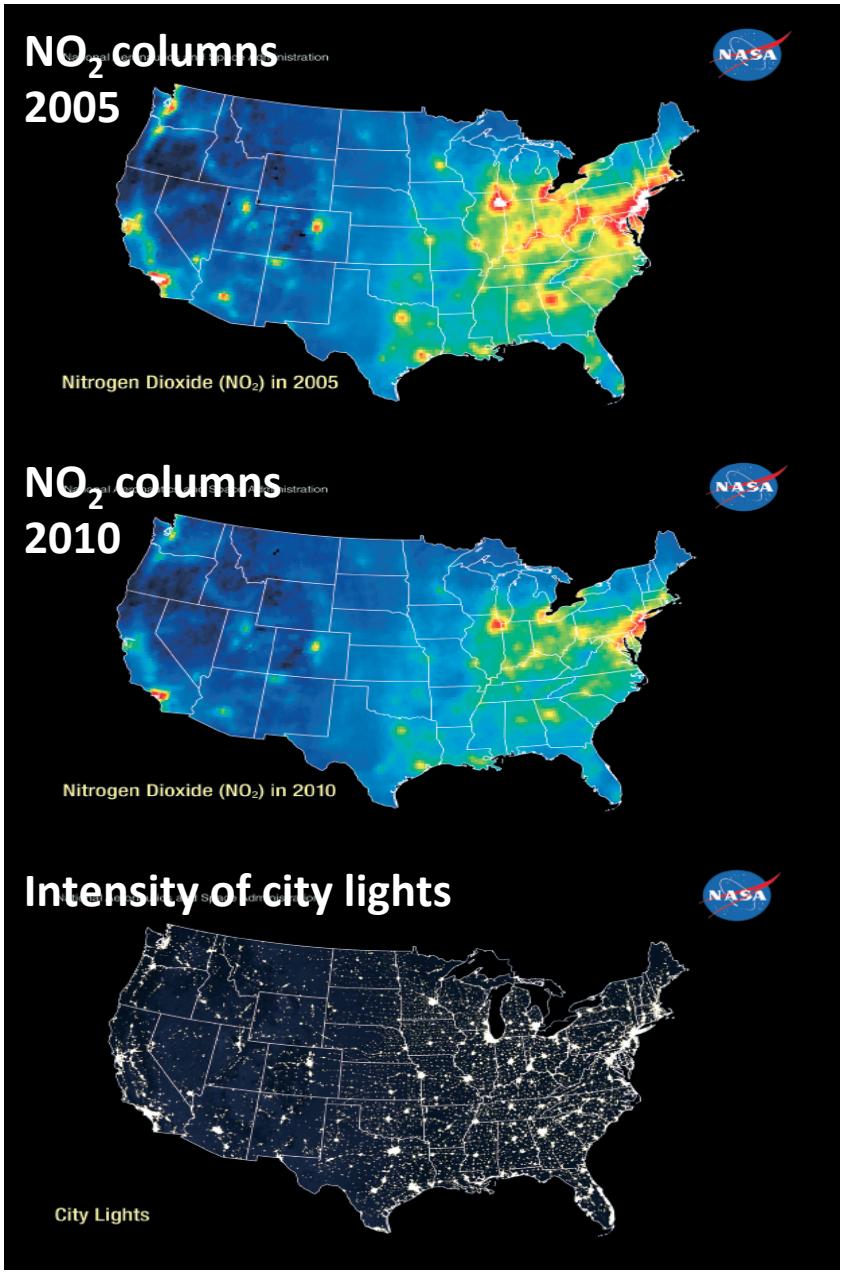
AQAST is a NASA team of atmospheric scientists working in partnership with US air quality managers to exploit the power of Earth Science tools to address air quality issues. We conduct a wide range of projects using satellite data, suborbital data, and models, and work with air quality agencies from the local to the national level. Please browse through this web site to see what AQAST is all about!

**Home** **What is AQAST?** **Members** **Projects** **Publications** **Events** **Newsletter**

- **Newsletter: subscribe through website**

## AQAST newsletter January 2012

Welcome to the January 2012 newsletter of the NASA Air Quality Applied Sciences Team (AQAST). This bimonthly newsletter keeps you to date on AQAST publications, activities, and events. Catch up by reading previous newsletters. Visit regularly the AQAST website for more detailed information on ongoing projects. Subscribe/unsubscribe to this newsletter by email to Bob Yantosca.




# Communication Tools

The AQAST Lenticular:
Tilt the card and see 3 images!

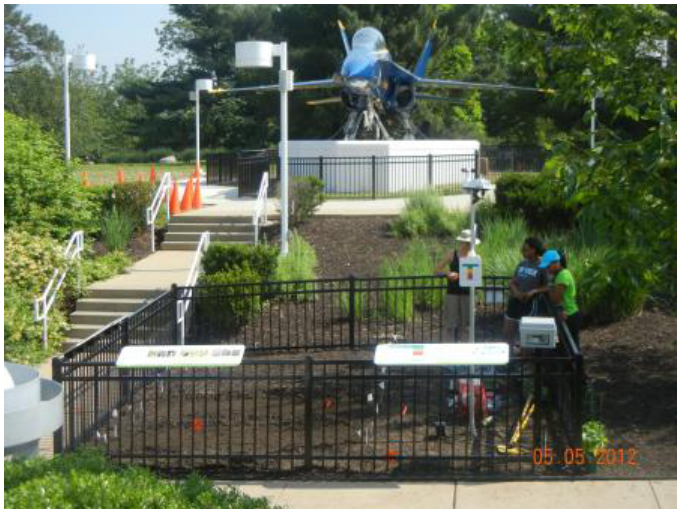
Low-tech but popular tool to advertise:

- Success of US air quality regulations
- Capability of satellites to detect pollution from space
- AQAST mission and goals.

**OMI $NO_2$ columns, x$10^{15}$ molecules $cm^{-2}$**

# Take-home messages

- AQAST provides a bridge between NASA science resources and air quality management.
- All AQAST projects are conducted in close partnership with air quality management partners.
- AQAST is always seeking to increase its effectiveness in serving the needs of air quality managers.
- If you have a specific problem for which you need information or assistance please contact team leader Daniel Jacob.



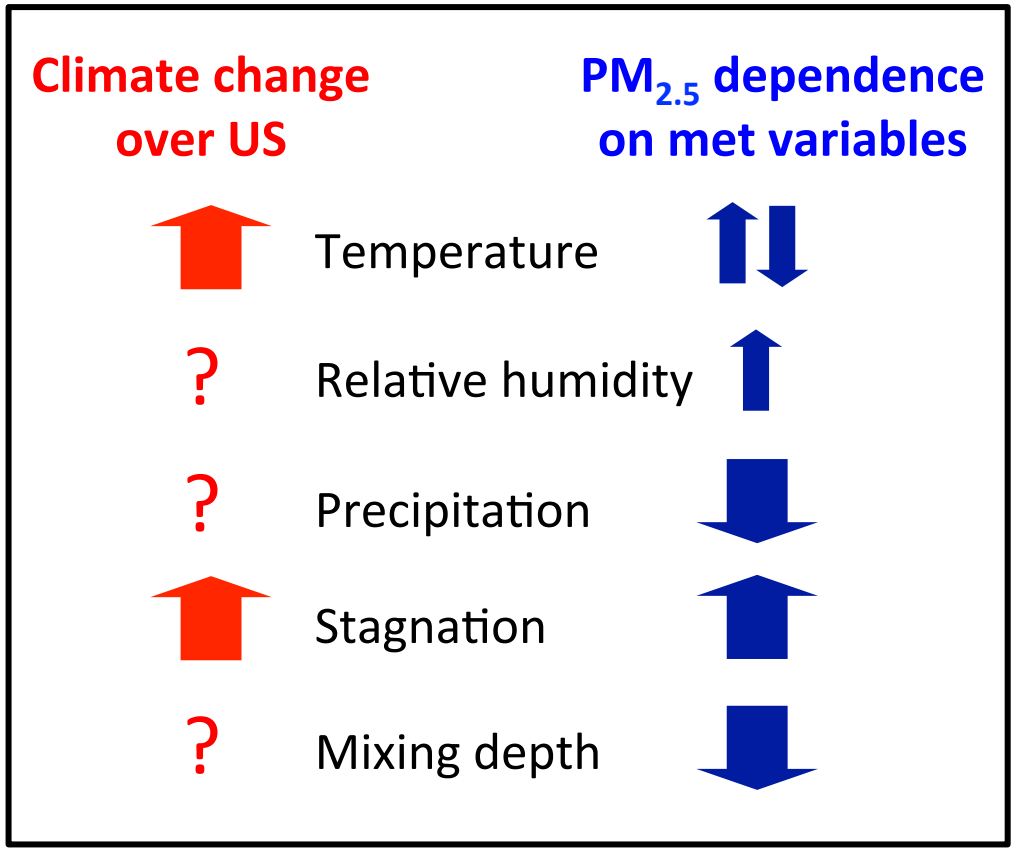

AQAST
NASA Air Quality Applied Sciences Team

Ozone garden at the Missouri Botanical Gardens

The dependence of $PM_{2.5}$ on meteorological variables is complex.

Different components have different sensitivities.

Model projections have uncertainties.




**AQ management tool**

CMIP3 archive of daily meteorology: 15 IPCC models

Apply observed relationships between $PM_{2.5}$ and met fields

AQ response to climate change

# *AQAST Year 1 Highlight:* Air quality workshops

- Physical Atmosphere Advisory Group Spring 2012 Meeting (Atlanta, Apr 2012)

**AQAST PI R.T. McNider**

  - Examine the difficulties of AQ models have representing the physical atmosphere
  - Assess value of satellite data for addressing these difficulties

- Using remote sensing data for air quality applications (U. Wisconsin, March 2012)

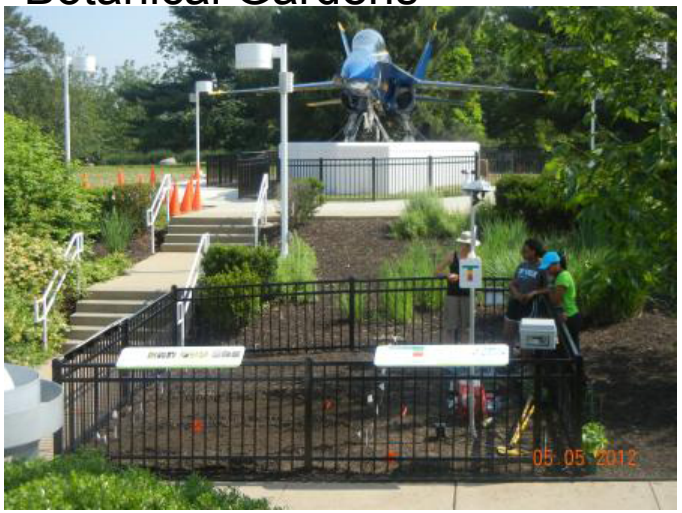
**ARSET/LADCO with AQAST PIs T. Holloway, B. Pierce, G. Carmichael**

  - New WHIPS software for regional model evaluation and analysis of OMI $NO_2$
  - Strategies for comparing satellite and model data

# *AQAST Year 1 Highlight:* The Saint Louis Ozone Garden

An education and public outreach AQAST activity

Ozone garden at the Missouri Botanical Gardens




Planting the garden


One of four explanatory signs


Educating the public on ozone pollution effects on plants

**AQAST PI: J.G. Fishman**